



Sexual Medicine

Sulcus Nervi Dorsalis Penis/Clitoridis: Anatomic Structure and Clinical Significance

Jiri Šedý^{a,b}, Ondrej Naňka^a, Marta Belišová^a, Jon M. Walro^{a,c}, Ladislav Jarolím^{d,*}

^aInstitute of Anatomy, 1st Medical Faculty, Charles University, Prague, Czech Republic

^bInstitute of Experimental Medicine, ASCR, Prague, Czech Republic

^cDepartment of Anatomy, Northeastern Ohio Universities College of Medicine (NEOUCOM), Rootstown, OH, United States

^dDepartment of Urology, 2nd Medical Faculty and University Hospital Motol, Charles University, Prague, Czech Republic

Article info

Article history:

Accepted February 6, 2006

Published online ahead of
print on February 24, 2006

Keywords:

Alcock syndrome
Dorsal nerve of clitoris
Dorsal nerve of penis
Pubis

Abstract

Objectives: The aim of this study was to correlate the anatomic and clinical significance of the prepubic course of dorsal nerve of penis and its groove on the pubic bone from the perspective of the surgeon.

Methods: The course of the dorsal nerve of the penis/clitoris was studied in six male and six female formalin-fixed cadavers. Several parameters of the pubis were quantified and analysed in 286 isolated pelvises.

Results: The course of the dorsal nerve of the penis is described in detail. This pubic sulcus was present in a majority of the pelvises examined. The dorsal nerve of the penis filled this groove, which we term the “sulcus nervi dorsalis penis/clitoridis.” In contrast, the dorsal nerve and artery of the clitoris coursed in this groove in women.

Conclusions: The course of dorsal nerve of the penis is described in detail including a previously unreported pubic structure—“sulcus nervi dorsalis penis/clitoridis.” In the majority of individuals, the dorsal nerve of the penis/clitoris courses through the sulcus in the pubis. Based on the anatomy of the pelvic region, compression of the dorsal nerve is more apt to occur at the inferior border of the pubis or in the pubic sulcus than in the pudendal canal.

© 2006 European Association of Urology. Published by Elsevier B.V. All rights reserved.

* Corresponding author. Department of Urology, 2nd Medical Faculty and University Hospital Motol, Charles University, V Úvalu 84, 150 06, Prague 5, Czech Republic.
Tel.: +420 224434804; Fax: +420 224434820.

E-mail address: ladislav.jarolim@lfmotol.cuni.cz (L. Jarolím).

1. Introduction

The pudendal nerve and its branches such as the dorsal nerve of the penis/clitoris have important

clinical significance. These nerves are subject to compression or entrapment or are subject to injury during operative procedures. Initially, the aim of this research was to trace the course of the dorsal nerve

of the penis/clitoris to prevent its damage during surgery. However, we observed that a segment of the nerve coursed in a distinct groove on the pubis and focused on the clinical importance of this site. Based on detailed analysis of the anatomy of this region, the inferior border of the pubis may be a site where nerves that innervate the penis are subject to compression.

2. Materials and methods

2.1. Neuroanatomic dissections

Dissections of dorsal nerve of penis/clitoris were performed on six male and six female formalin-fixed cadavers (age, 52–86 yr) using $\times 2.5$ operating loupes or a $\times 15$ – 30 operating microscope. Pelvises were removed and dissected separately using inferomedial and perineal approaches. In the inferiomedial approach, the dorsal nerve of penis/clitoris was located near its origin from pudendal nerve proximal to the infrapiriform foramen, and together with the accompanying arteries and veins, was dissected throughout its entire course. In the inferior approach, the dorsal nerve of penis was located as described above and all its major branches were followed to their target tissues.

2.2. Analysis of sulcus nervi dorsalis penis/clitoridis from skeletal specimens

The sulcus nervi dorsalis penis/clitoridis was traced in 168 male and 118 female specimens from the collection at the Institute of Anatomy, Prague. Pubic bones were categorized into one of three classes according to the presence or absence of a sulcus and length of the sulcus (Table 1).

We measured seven parameters of the pubis and sulcus: the craniocaudal length of symphysis (LoSy), mediolateral width of symphysis (WoSy), distance between pubic tubercle and acetabulum (PT-A), distance between pubic tubercle and ischial tuberosity (PT-IT) according to Novotný [1] and three new parameters: craniocaudal length of sulcus nervi dorsalis penis/clitoridis on anterior surface of pubis (LoSu), maximal

mediolateral width of sulcus nervi dorsalis penis/clitoridis on anterior surface of pubis (WoSu), and length of the sulcus nervi dorsalis penis/clitoridis on inferior pubic ramus (LoSu-r). Class I and II sulci were compared for both males and females using a two-tailed *t* test with the minimum level of significance set at $p < 0.05$. No differences were noted in class I and II sulci; hence, data were pooled within a gender for subsequent analyses (male vs female).

3. Results

3.1. Dorsal nerve of the penis

The dorsal nerve of penis emerges from pudendal nerve approximately 1 cm dorsal to its entrance into the pudendal canal and courses in the cranial part of pudendal canal surrounded by fat of the ischiorectal fossa. After leaving the pudendal canal anteriorly, the dorsal nerve of the penis continues cranially where it initially contacts the inferior ramus of the pubis and subsequently courses along the inferior border and anterior surface of body of the pubis. Inferior to the pubis, the dorsal nerve of penis courses proximal to the insertion of the cavernous body and then between the cavernous body and the anterior surface of pubis to the dorsum penis. Here, the dorsal nerve of penis branches and innervates the penile shaft and glans (Fig. 1).

A distinct groove on the inferior ramus and anteroinferior surface of body of pubis accommodates the dorsal nerve of penis (Fig. 2). We have termed this groove the “sulcus nervi dorsalis penis.” The dorsal artery of penis and the veins of the subpubic space course anterolateral to this groove.

3.2. Dorsal nerve of the clitoris

The course of the dorsal nerve of clitoris and its position relative to the inferior ramus of the pubis are similar to that of the dorsal nerve of penis. The dorsal artery of clitoris arrives from the inferolateral direction and craniomedially crosses the dorsal nerve before it reaches the inferior ramus of pubis. The dorsal artery lies medial to the nerve and accompanies it along the anterior surface of the pubis; hence, the sulcus, termed the “sulcus nervi dorsalis clitoridis,” is wider in females than in males (Figs. 1 and 2).

3.3. Incidence of sulci in pubic bones

Sulcus nervi dorsalis penis/clitoridis were present in approximately 72% of male and 83% of female pubic bones (Table 1). The distribution of sulci into classes I, II, and III deviated significantly from randomness

Table 1 – Criteria for classification of sulcus nervi dorsalis penis/clitoridis and classification of pubic bones based on the presence (classes I and II) or absence (class III) of a sulcus nervi dorsalis penis/clitoridis

Class	I	II	III
SNDP/SNDC	Present	Present	Absent
Constitution	Complete	Incomplete	Absent
Length	>1/3 of pubis	<1/3 of pubis	NA
Depth	1.5 mm and more	0.2–1.5 mm	NA
No. of males	81 (48.2%)	40 (23.8%)	47 (28.0%)
No. of females	72 (61.0%)	26 (22.0%)	20 (17.0%)
Total no.	153 (53.5%)	66 (23.1%)	67 (23.4%)

Note that most male and female pubic bones exhibited a sulcus. SNDP/SNDC = sulcus nervi dorsalis penis/clitoridis; NA = not applicable.

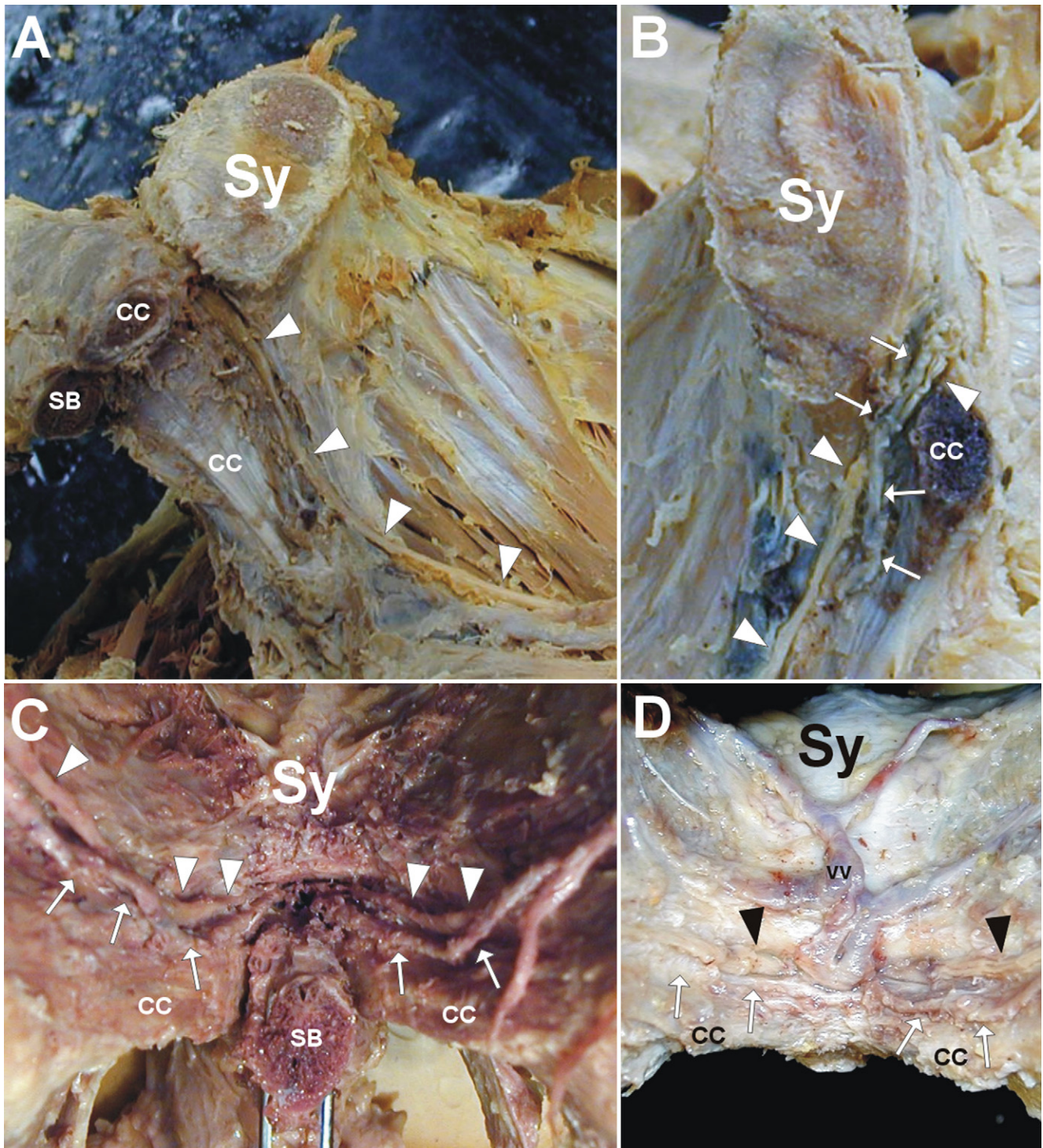


Fig. 1 – Dorsal nerve of penis and dorsal nerve of clitoris. (A) Dorsal nerve of penis (arrowheads) from medial side. CC = cavernous crus, SB = spongiosus body, Sy = symphysis. (B) Dorsal artery of clitoris (arrows) crossing dorsal nerve of clitoris (arrowheads), reaching its medial aspect. CC = cavernous crus, Sy = symphysis. (C) Dorsal nerve of penis (arrowheads) and dorsal artery of penis (arrows) from inferior view. CC = cavernous crus, SB = spongiosus body, Sy = symphysis. (D) Crossing of dorsal nerve of clitoris (arrowheads) and dorsal artery of clitoris (arrows) from inferior view. Retropubic venous plexus (vv) also visible. CC = cavernous crus, Sy = symphysis.

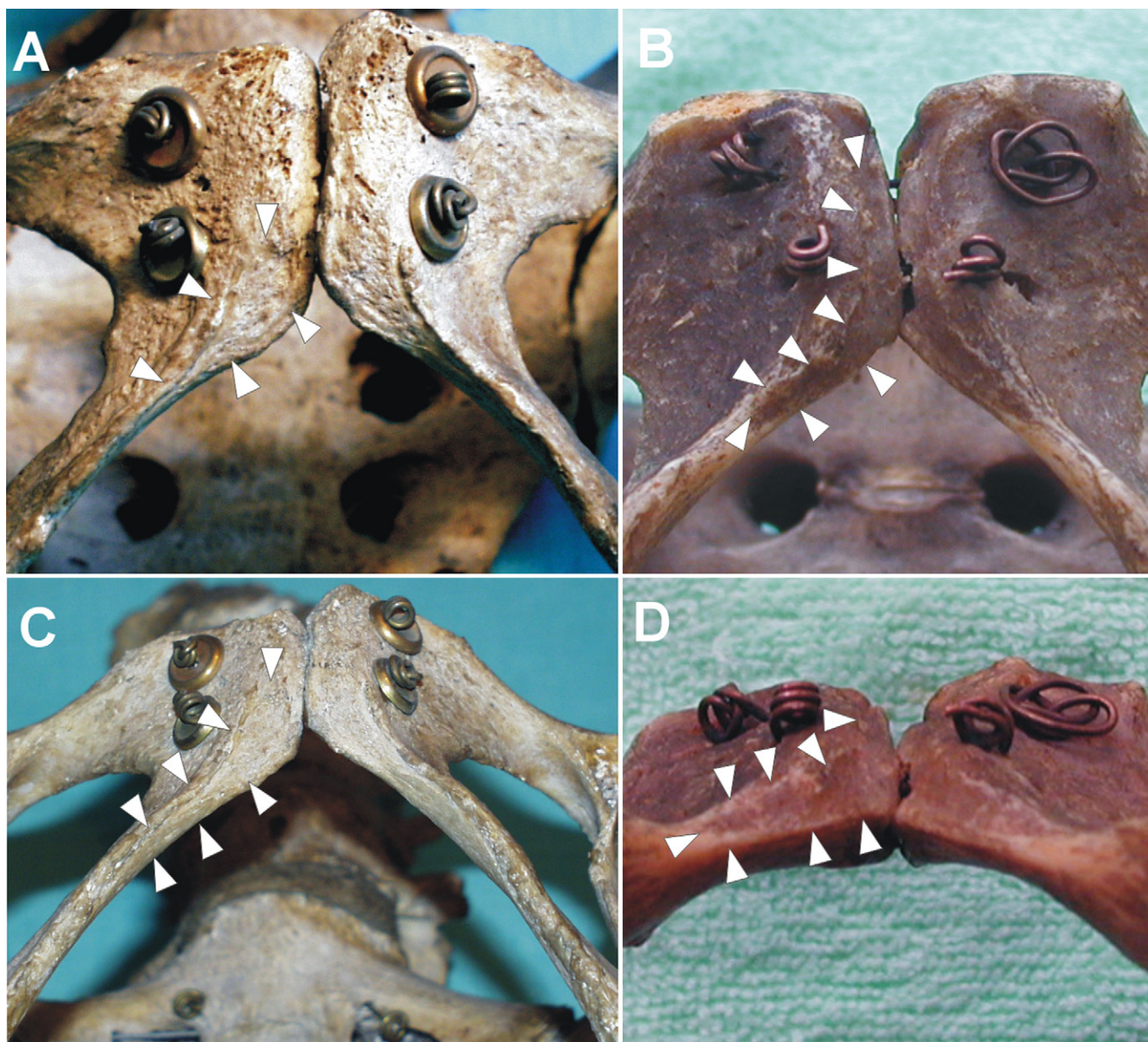


Fig. 2 – Sulcus nervi dorsalis penis/clitoridis on pubic bone. (A) Sulcus nervi dorsalis clitoridis (arrowheads) from anterior view. (B) Sulcus nervi dorsalis penis (arrowheads) from anterior view. (C) Sulcus nervi dorsalis clitoridis (arrowheads) from ventrocaudal view. (D) Sulcus nervi dorsalis penis (arrowheads) from ventrocaudal view.

($p < 0.001$) for both males and females, and differences in male/female distributions into the three classes approached statistical significance ($\chi^2 = 5.8$; $p = 0.055$).

3.4. Quantitative analysis of the sulcus nervi dorsalis penis

The sulcus nervi dorsalis penis were visible on the inferior ramus of pubis for a mean distance of 15.8 ± 3.8 mm from the inferior border of pubis (Table 2). Sulci continued on the inferior border of the pubis and curved to the anterior surface of the

body of the pubis for a mean distance of 21.3 ± 5.3 mm. Sulci coursed cranially and parallel to the pubic symphysis. The mean length of the sulcus was 55% of the total craniocaudal length of the anterior surface of symphysis. The cranial end of the sulcus marked the site of anterior curving of the nerve to the penile dorsum.

3.5. Sulcus nervi dorsalis clitoridis

The sulcus nervi dorsalis clitoridis followed a similar course as in males. Its mean length on inferior ramus of pubis was 0.8 mm longer than in males.

Table 2 – Measurements (mm) of pubis and sulcus nervi dorsalis penis/clitoridis and comparison of male and female pubis and sulcus nervi dorsalis penis/clitoridis

Class	Males			Females			Mean difference
	I	II	I + II	I	II	I + II	
LoSy	38.8 ± 4.3	37.8 ± 4.5	38.4 ± 4.3	34.6 ± 3.4	35.3 ± 7.4	34.8 ± 4.3	3.6***
WoSy	14.1 ± 2.3	14.7 ± 2.3	14.4 ± 2.4	12.2 ± 2.1	12.6 ± 3.5	12.2 ± 2.4	2.2***
PT-A	69.1 ± 6.4	69.5 ± 4.6	69.2 ± 5.7	72.4 ± 4.5	73.1 ± 3.6	72.5 ± 4.3	–3.3**
PT-IT	120.4 ± 6.6	119.5 ± 6.0	120.0 ± 6.4	119.4 ± 5.4	121.4 ± 4.7	119.8 ± 5.4	0.2
LoSu	22.4 ± 5.9	19.8 ± 3.8	21.3 ± 5.3	20.3 ± 4.6	17.7 ± 3.4	19.8 ± 4.5	1.5
WoSu	5.2 ± 1.4	4.8 ± 1.4	5.0 ± 1.4	7.5 ± 1.6	7.1 ± 1.2	7.4 ± 1.5	–2.4***
LoSu-r	16.1 ± 3.8	15.4 ± 3.7	15.8 ± 3.8	17.0 ± 3.0	15.2 ± 3.0	16.9 ± 3.0	–1.1
Sample size (N)	81	40	121	72	26	98	

Classes I and II were pooled for both males and females. LoSy = craniocaudal length of symphysis; WoSy = mediolateral width of symphysis; PT-A = minimal distance between pubic tubercle and border of acetabulum; PT-IT = distance between pubic tubercle and ischial tuberosity; LoSu = craniocaudal length of sulcus nervi dorsalis penis/clitoridis on anterior surface of pubis; WoSu = maximal mediolateral width of sulcus nervi dorsalis penis/clitoridis on anterior surface of pubis; LoSu-r = length of sulcus nervi dorsalis penis/clitoridis on inferior pubic ramus. No significant differences were noted between classes within males or females; hence, classes were pooled within males and females for subsequent analyses. *, **, and *** denote a significant difference between males and females at $p > 0.05$, 0.01, and 0.001, respectively.

The sulcus nervi dorsalis clitoridis on the inferior ramus of the pubis was thinner than the corresponding groove in males. However, the mean mediolateral diameter of sulcus nervi dorsalis clitoridis on the anterior surface of body of the pubis is 1.5 times wider than the groove in males due to the dorsal artery of the clitoris accompanying the nerve. The length of the sulcus expressed as a percent of the length of symphysis (57%) was equivalent to that observed in males.

4. Discussion

4.1. Sulcus nervi dorsalis penis/clitoridis

The proximity of the dorsal nerve of penis, and the dorsal nerve and artery of clitoris to the pubic bone is well documented [2–5]. However, the present study is the first to describe the presence of a sulcus on the inferior border of the pubis, to quantify its incidence and size in isolated pubic bones of both genders, and to hypothesize its clinical significance.

4.2. Sulcus nervi dorsalis penis and Alcock syndrome

Pudendal nerve compression syndrome, also known as Alcock syndrome, is characterized by decreased glandular and penile sensitivity, and erectile dysfunction [6–8]. This syndrome, commonly observed in cyclists, is due to nerve irritation caused by direct pressure of the nose of the saddle against the perineum and the symphysis. The forward leaning of a cyclist pinches the pudendal nerves at the point where they emerge below the pubis [9]. Although Alcock syndrome is generally assumed to result

from a compression of the pudendal nerve in the pudendal canal, several authors [10–12] have speculated that compression of the nerve might occur at the inferior border of pubis rather than in the pudendal canal. The pudendal canal is covered by a thicker mass of fat than the inferior border of body of pubis. The additional fat would serve to protect the nerve. In addition, irritation or damage of pudendal artery and vein would be expected if compression occurs in the pudendal canal. However, haematoma or other signs of vessel damage are not symptomatic of Alcock syndrome. Hence the absence of vessel damage is consistent with the hypothesis that compression of the nerve occurs at the inferior border of the pubis or in the sulcus.

Additional evidence supports the hypothesis that Alcock syndrome results from compression at the inferior border of the pubis rather than in the pudendal canal. The perineal nerve, another branch of pudendal nerve, passes through the Alcock canal and between the ischiocavernosus and bulbocavernosus muscles to innervate the bulbocavernosus muscle [13]. If compression were to occur in the pudendal canal, paresis of the bulbocavernosus muscle should be one of the symptoms. Paresis of the bulbocavernosus muscle is not observed in individuals with Alcock syndrome. Anatomically, the dorsal nerve of the penis is purely sensory, and hypaesthesia or anaesthesia are prominent symptoms of Alcock syndrome. These observations further support the hypothesis that Alcock syndrome is caused by irritation of dorsal nerve of penis in sulcus nervi dorsalis penis on the inferior border of body of pubis.

Pudendal nerve entrapments are sources of intractable perineal pain [14–16]. It is unlikely that

compression of the dorsal nerve in the pubic sulcus is the source of this pain. The dorsal nerve of the penis is sensory and desensitization of penile dorsum and erectile dysfunction have not been reported in these cases. A more probable source for this pain is compression of perineal and inferior rectal nerves in the inferior half of the pudendal canal.

4.3. Potential injury to the dorsal nerve of the penis

Proper surgical fixation of dorsal nerve of the penis that preserves the innervation to a neoclitoris is a major concern in male-to-female gender reassignment [17]. Damage to the nerves and vessels can lead to necrosis or numbing of the neoclitoris. If this occurs, orgasm is blocked. To prevent damage to the nerve, meticulous dissection of the dorsal neurovascular bundle is required to gently liberate the bundle from the glans proximally. This dissection is more difficult in cases with a deep intercrural groove in its proximal end. Surgical resection of crura of cavernous bodies must be complete because any remnants can form a barrier that causes problems during intercourse. However, care must be taken not to ligate or pierce the nerve when haemostatic sutures are located proximal to the course of pudendal nerve in the vicinity inferior ramus of pubis. Gender reassignment is one of several procedures with a risk of injury to the dorsal nerve of the penis. Other procedures include nerve blockade during circumcision, repair of pelvic fractures, or rerouting of the urethra [18,19].

4.4. Potential for injury to the dorsal nerve/artery of the clitoris

An understanding of the anatomic relationships of the dorsal nerve of the clitoris to soft tissues and pelvis is essential in the reconstructive surgery of female genitourinary system, such as reduction clitoridoplasty with mobilization and preservation of neurovascular bundle [5,20] or insertion of transobturator vaginal tape [21]. Operative injury to the dorsal nerve of clitoris may cause complete insensitivity of clitoris resulting in decreased satisfaction during intercourse. Correspondingly, injury to the dorsal artery of clitoris might cause intraoperative bleeding or postoperative haematoma.

5. Conclusions

The dorsal nerve of the penis/clitoris and the dorsal artery of the clitoris course through a groove on the

inferior surface of the pubis that we have termed the “sulcus nervi dorsalis penis/clitoridis”. A better understanding of topography of the pubic region facilitates urologic surgery and clarifies the potential sites of nerve compression syndromes in the pelvic region.

References

- [1] Novotný V. Sex determination of the pelvic bone: a system approach. *Antropologie (Brno)* 1986;24:197–206.
- [2] Yang CC, Bradley WE. Peripheral distribution of the human dorsal nerve of the penis. *J Urol* 1998;159:1912–7.
- [3] Shafik A, Doss SH. Pudendal canal: surgical anatomy and clinical implications. *Am Surg* 1999;65:176–80.
- [4] Akman Y, Liu W, Li YW, Baskin LS. Penile anatomy under the pubic arch: reconstructive implications. *J Urol* 2001;166:225–30.
- [5] Baskin LS, Erol A, Li YW, Liu WH, Kurzrock E, Cunha GR. Anatomical studies of the human clitoris. *J Urol* 1999;162:1015–20.
- [6] Sommer F, König D, Graft C, et al. Impotence and genital numbness in cyclists. *Int J Sports Med* 2001;22:410–3.
- [7] Taylor JA, Kao TC, Albertsen PC, Shabsigh R. Bicycle riding and its relationship to the development of erectile dysfunction. *J Urol* 2004;172:1028–31.
- [8] Dettori JR, Koepsell TD, Cummings P, Corman JM. Erectile dysfunction after a long-distance cycling event: associations with bicycle characteristics. *J Urol* 2004;172:637–41.
- [9] Leibovitch I, Mor Y. The vicious cycling: bicycling related urogenital disorders. *Eur Urol* 2005;47:277–87.
- [10] Amarenco G, Lanoe Y, Perrigot M, Goudal H. A new canal syndrome: compression of the pudendal nerve in Alcock's canal or perineal paralysis of cyclists. *Presse Med* 1987;16:399.
- [11] Goodson JD. Pudendal neuritis from biking. *N Engl J Med* 1981;304:365.
- [12] Oberpenning F, Roth S, Leusmann DB, van Ahlen H, Hertle L. The Alcock syndrome: temporary penile insensitivity due to compression of the pudendal nerve within the Alcock canal. *J Urol* 1994;151:423–5.
- [13] Yang CC, Bradley WE. Somatic innervation of the human bulbocavernosus muscle. *Clin Neurophysiol* 1999;110:412–8.
- [14] Ramsden CE, McDaniel MC, Harmon RL, Renney KM, Faure A. Pudendal nerve entrapment as source of intractable perineal pain. *Am J Phys Med Rehabil* 2003;82:479–84.
- [15] Robert R, Prat-Pradal D, Labat JJ, et al. Anatomic basis of chronic perineal pain: role of the pudendal nerve. *Surg Radiol Anat* 1998;20:93–8.
- [16] Robert R, Labat JJ, Bensignor M, et al. Decompression and transposition of the pudendal nerve in pudendal neuralgia: a randomized controlled trial and long-term evaluation. *Eur Urol* 2005;47:403–8.
- [17] Jarolim L. Surgical conversion of genitalia in transsexual patients. *BJU Int* 2000;85:851–6.

-
- [18] Bleustein CB, Fogarty JD, Eckholdt H, Areyyo JC, Melman A. Effect of neonatal circumcision on penile neurologic sensation. *Urology* 2005;65:773–7.
- [19] Andrich DE, O'Malley KJ, Summerton DJ, Greenwell TJ, Mundy AR. The type of urethroplasty for a pelvic fracture urethral distraction defect cannot be predicted preoperatively. *J Urol* 2003;170:464–7.
- [20] Baskin LS. Anatomical studies of the female genitalia: surgical reconstructive implications. *J Pediatr Endocrinol Metab* 2004;17:581–7.
- [21] Bonnet P, Waltregny D, Reul O, de Leval J. Transobturator vaginal tape inside out for the surgical treatment of female stress urinary incontinence: anatomical considerations. *J Urol* 2005;173:1223–8.